ROCHESTER INSTITUTE OF TECHNOLOGY

P12401 WECEB Test Plans

Senior Design

2/15/2012

This document contains test plans for Senior Design team P12401. The team is responsible for wind energy collection to battery bank (WECEB).

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PCB Test Plans

-The electrical test plans contain critical procedures to make sure each individual circuitry would work before finalizing/buying PCB from manufacture to avoid buying costly printed circuit board repeatedly.

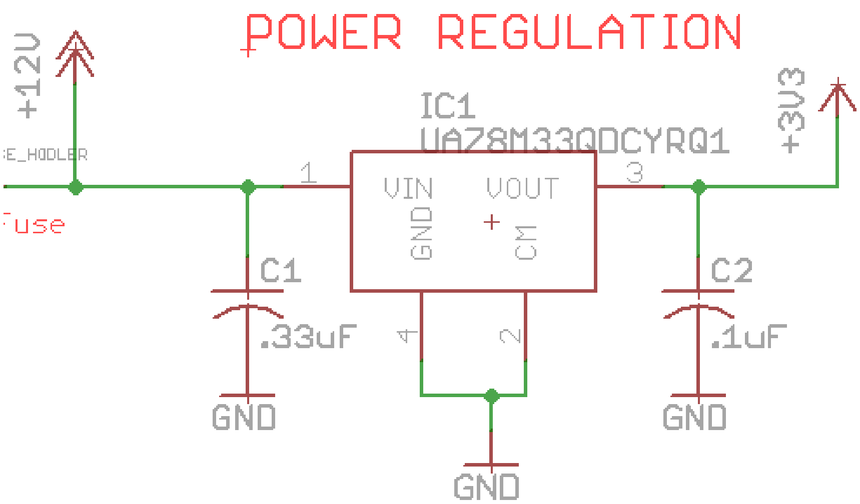
Items Needed

The following items would be needed throughout the verification processes of each individual circuitry.

1. Power Supply that can deliver from 0V to 18 V at 500 mA and 3.3V simultaneously
2. Digital Multimeter that has accuracy of at least 10mV DC voltage and 1mA of DC Current
3. Soldering Iron and solder
4. Breadboard
5. Oscilloscope

Verification of Power Regulation

Schematics



Procedures

1. Solder 18 gauge wires to the 4 pins on IC1, the schematics is shown above
2. Check to see if the output is 3.3 V, check the voltage ripple, check the noise
3. Varied the input voltage from 0V to 18 V to see the input voltage range

Results/Check Marks

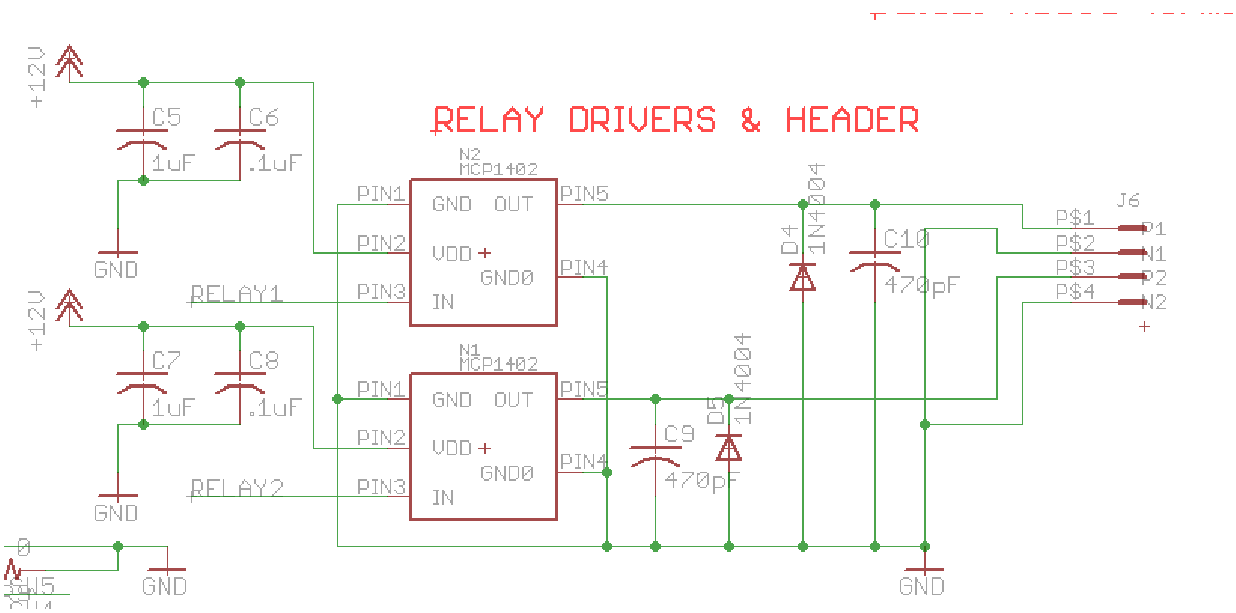
Input Voltage Range	4.95V- 18 V
Output DC Voltage	3.2V
Output Voltage Ripple	25 mV
Noise Ratio	0.781 %

Comments

The working input voltage range is actually lower than what the datasheet shows. The output voltage is stable enough for utilization by the MCU.

Verification of Relay Control Circuitry

Schematics



Procedures

1. Solder wires into leads on MCP1402 as shown above. **(Make sure the wire is 400mA rated)**
2. Connect VDD to 12V limited at 300mA
3. Connect IN to 3.3V on/off PSU terminal
4. Capture the waveform in the output or Pin5
5. Connect a dummy load in the output rated at **1 Watt**
6. Vary Vdd to see how power would be changed in the output

Results/Checklist

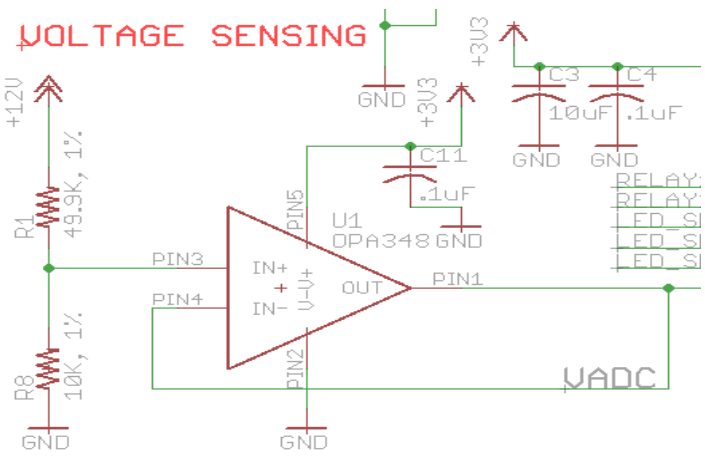
Toggle the Output between 0V and 12V?	☒
Current Sinking into the input/Pin3	Too Small to see. Sub uA range
Current Sinking into the relay load at 12V	80 mA
Vdd Power Consumption at 12V	925 mW

Comments

The 800 mA fuse should be big enough since the relay only draws max of 1 watt at 12V or 83.3mA

Verification of Voltage Sensing Circuitry

Schematics



Procedures

1. Solder wires to lead as shown above except vdd/pin5 and in+/pin3.
2. Connect Vdd to 3.3V.
3. Connect the input/Pin3 of OPA348 to PSU vary from 0 V to 3.3V limited at 3mA
4. Capture the waveform in the output.
5. Record the clipping voltage in the output and noise
6. Record the voltage ripple in the input and output at the same time when input is about 1.6V

Results

Linear Voltage Range(No Clipping)	Gnd to Vdd at 3.3V
Power Consumption	Less than 1 mW
Input voltage ripple at about 1.6V	20 mV
Output voltage ripple at about 1.6V	10 mV

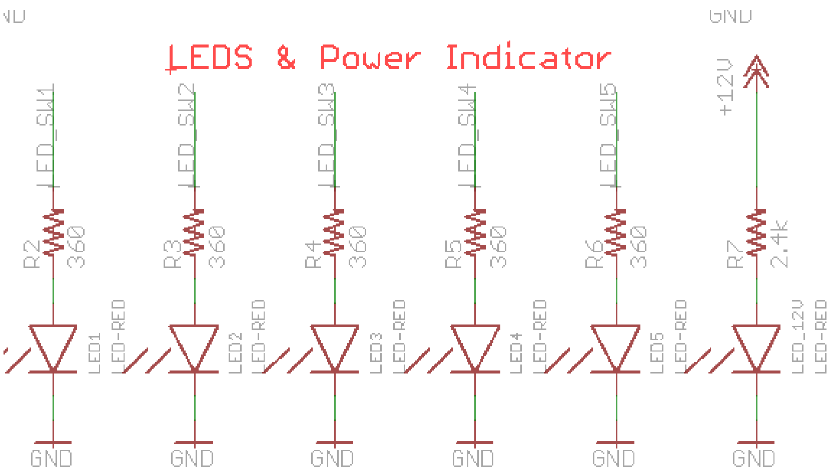
Comments

The opamp is a rail to rail input and rail to rail output amplifier with very low bias current (0.5 pA).

Also, ripple voltage is questionable since the probe might be carrying noise. But 20 mV of ripple is still good enough.

Verification of LEDs

Schematics



Procedures

1. Solder wire into a single red/green LED as shown above. The input needs to be rate at 3.3V limited at 5mA
2. Put the multi-meter inline with the led to check the current
3. Check to see how much power is consumed at 3.3V
4. Check to see if the green/red LED are bright enough

Results/Checklist

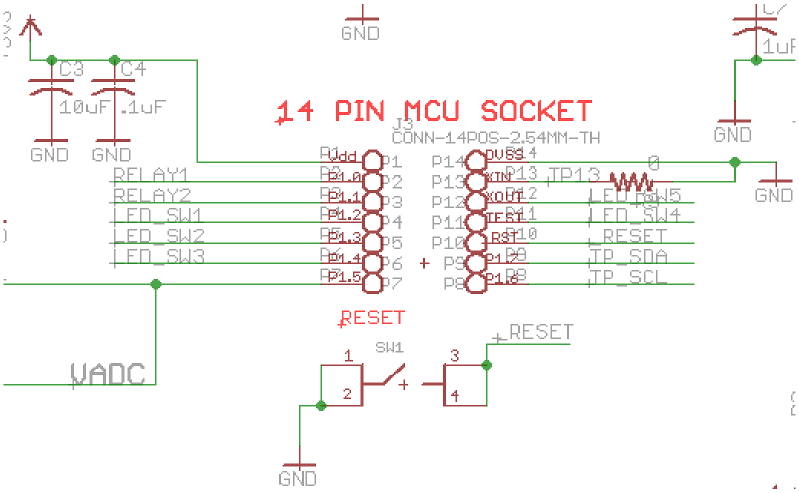
-Please, double click the checkbox to check

Power Consumption (Red)	~5 mW
Power Consumption (Green)	~ 5 mW
Red LED bright enough?	☒
Green LED bright enough?	☒

Comments

The LED is bright enough indoor. The brightness of LED outdoor under very bright sunny light might be questionable.

Verification of MCU IN BREADBOARD



Procedures

1. Program the MCU in Launchpad
2. Place the MCU in the breadboard
3. Perform ADC Reading
4. Check ADC accuracy
5. Charge indication by toggling LED
6. Reset Switch
7. I2C peripherals Interfacing (Future Modularity)

Results/Check Marks

-Please, double click the checkbox to check

ADC start reading?	☐
Toggling LED?	☒
Reset Switch Working?	☒
IC2 Peripheral Working?	☐

Comments

A pull up resistor is added to reset switch since there is no internal pull up circuitry inside the MCU. I2C Peripheral will not be implemented. However the pins are carried out as test points.

Mechanical Test Plans

-The turbine test plans are performed prior to mass production in order to properly characterize how well the turbine would perform under varying wind speed condition. Stress test the turbine to see how well it performs.

Verification of Wind Turbine Output to Wind Speeds

Items Needed

- Turbine hub assembly and MPPT controller
- Necessary wiring between turbine, MPPT, and battery
- Hand drill with max RPM of 1000
- Hex drill bit to fit in turbine hub center
- Amstron 75 Ah sealed lead acid battery
- 2 Digital Multimeters that have accuracy of at least 10mV DC voltage and 1mA of DC Current
- Pen/Paper to record data
- 2-3 people

Procedures

1. Assemble WECEB system
2. Attach multimeters to measure voltage of the battery and current generated by turbine output
3. Attach integral wires of the WECEB system
4. Put drill bit into hub center and max out the drill's throttle to 1000 RPM
5. Record the multimeters' current and voltage readings
6. Multiply the current by the voltage to get total power being output.

Results

Compare team's generated power to the average power needed (20.64 Watts)

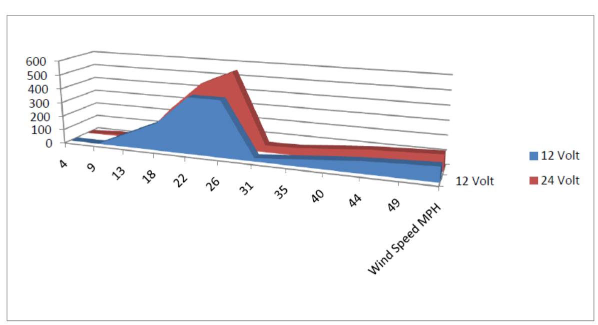
____12.51____ Volts x ____4.15____ Amps = ____51.91____ Watts

Does power generated at 1000 RPM exceed 20.64 Watts? (Y/N) **YES**

Comments

Assuming the Nature Power power curve is correct, a power output of 51.91 Watts would suggest that the corresponding wind speed is roughly 12 mph or 5.36 m/s. While that wind speed is higher than average for Rochester, it is not uncommon. This wind turbine may very well exceed power requirements and expectations.

6.1 Performance Curves



Further Turbine Test Plans

Items Needed

The following items would be needed throughout the characterization processes

1. Digital Multimeter
2. Oscilloscope rated for the AC voltage in the three phase terminals
3. Anemometer
4. Sense Resistors

Procedure

1. Attach a single phase of the turbine to the positive connection of the oscilloscope.
2. Rotate turbine as a specific speed (varying with each run)
3. Capture the waveform using oscilloscope
4. Obtain voltage, frequency, and current for this phase
5. Repeat processes 1-4 for two other phases.
6. Repeat 1-5 for each varying turbine rpm
7. Record all data in spreadsheet
8. Plot the relationship between wind speed and, turbine rpm and 3 phase terminals

Results/Check Marks

Combination	Resistance(ohm)	Capacitance(F)
Black&Red	0.3	Infinite
Black&Yellow	Open	1nF
Black&Brown	0.3	infinite
Red&Yellow	Open	1nF
Red&Brown	0.3	infinite
Brown&Yellow	Open	1nF

Verification of the Temperature and Humidity Ranges

Items Needed

- Turbine hub assembly and MPPT controller
- Necessary wiring between turbine, MPPT, and battery
- Hand drill with max RPM of 1000
- Hex drill bit to fit in turbine hub center
- Amstron 75 Ah sealed lead acid battery
- 2 Digital Multimeters that have accuracy of at least 10mV DC voltage and 1mA of DC Current
- Pen/Paper to record data
- 2-3 people
- Cold day (close to freezing) for one test
- Rainy day (~100% humidity) for second test

Procedures

1. Place turbine hub assembly outside in the cold for at least 30 minutes
2. Bring the turbine inside and quickly assemble WECEB system
3. Attach multimeters to measure voltage of the battery and current generated by turbine output
4. Attach integral wires of the WECEB system
5. Put drill bit into hub center and max out the drill's throttle to 1000 RPM
6. Record the multimeters' current and voltage readings
7. Multiply the current by the voltage to get total power being output.
8. Repeat for a forecasted rainy, high humidity, day.

Results

Compare team's generated power to the average power needed (20.64 Watts)

Outside temperature = ___33 degrees Fahrenheit___

Outside humidity = ___97%___

___12.57___ Volts x ___4.02___ Amps = ___50.53___ Watts

Does power generated at 1000 RPM exceed 20.64 Watts? (Y/N) **YES**

Comments

Were able to test the temperature and humidity requirements at the same time.

Battery Test Plans

Characterize the charge-to-voltage correlation of the 75 AH Sealed Lead Acid Battery.

Items Needed

The following items would be needed throughout the characterization processes

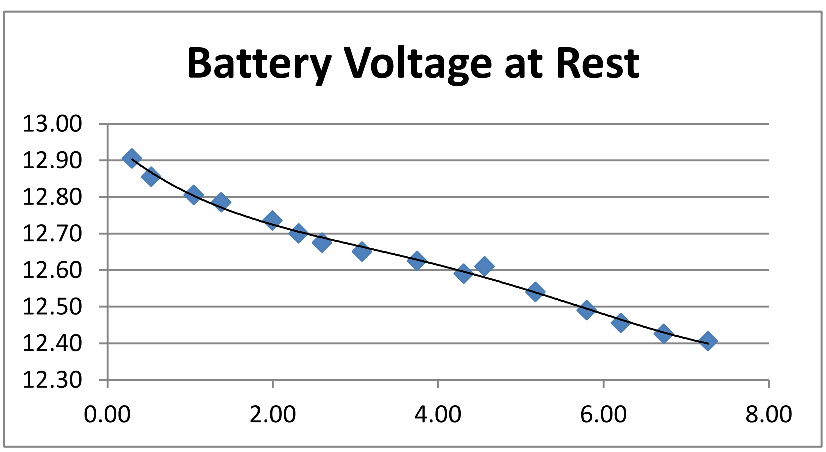
1. Digital Multimeter
2. Ammeter (or Multimeter with current reading)
3. Dump Load

Procedure

1. Take the fully charged SLA battery and connect it to the dump load.
2. Measure the current through the dump load
3. Measure the voltage across the battery terminals
4. Record current and voltage and calculate Watts/Hour
5. Let battery rest for 1 minute and measure rest voltage across the battery terminals.
6. Repeat steps 2-5 in periodic intervals until battery has output 40% of its total energy
7. Record the data into spreadsheet and create a graph of Voltage vs. Charge

Results

Current through Dump Load	4.3 - 4.22 (A)
Voltage across Dump Load	12.7 - 12.28 (V)
Time to Discharge 360 Watts (40%)	7.27 Hours
Battery Voltage at 60% capacity	12.4 (V)



Assembly Test Plans

Timing the Assembly of the WECEB System

Items Needed

- WECEB System unassembled
- Stop Watch
- 2-3 people (2 to assemble, 1 potentially to time and watch out for safety)

Procedures

1. Start stopwatch
2. Assemble WECEB system by team's user's manual
3. Stop stopwatch when assembly complete

Results

Time to assemble system	14:15 (Minutes:Seconds)
Time within 15-30 minutes?	Y/N **YES**